Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

BRIEFER ARTICLES.

THE STRUCTURE OF THE FLOWERS AND THE MODE OF POLLINATION OF THE PRIMITIVE ANGIOSPERMS.

THE purpose of this paper is to show how some questions involved in the phylogeny of angiosperms might be regarded from the point of view of the anthoecologist. The proposition to be offered is that the primitive angiosperms were entomophilous, and that the anemophilous ones are metamorphosed entomophilous flowers whose seemingly simple structures are degraded, not primitive.

The characteristic anemophilous flower has a pistil with a one-celled ovary containing a single ovule and ripening into a one-seeded indehiscent fruit. The characteristic entomophilous flower has a pistil with several ovules which ripens into a several-seeded dehiscent fruit. The explanation of the monospermy of the Anemophilae and the polyspermy of the Entomophilae is obvious when one considers the difference in the conditions of pollination. Even with a large plumose stigma the Anemophilae have enough to do to secure enough pollen for a single ovule. The Entomophilae with a small stigma can readily secure enough pollen for many ovules. The relation of many-seeded fruits to entomophilous pollination is emphasized in the orchids, where the high degree of polyspermy is correlated with the disposal of the pollen in masses. There are conditions under which entomophilous flowers become monospermous, and anemophilous flowers derived from them may show monospermy as an inherited character. But polyspermy is an entomophilous character.

Syncarpy involves polyspermy and is also an entomophilous character, the union of oligospermous fruits producing polyspermy. It is hard to imagine conditions under which an anemophilous plant would be likely to become syncarpous. Accordingly, in the absence of other entomophilous characters, and in spite of the presence of anemophily, plants may still retain the entomophilous characters of polyspermy and syncarpy. Syncarpy is important in diagnosing advanced stages of anemophilous metamorphosis because indications of syncarpy may be the only remaining evidence of a previous polyspermous condition. I also regard highly specialized inflorescences as entomophilous. At any rate, a highly specialized inflorescence is no place to look for simple structures.

According to their stages of development, three sets of anemophilous plants may be recognized: (1) those closely related to entomophilous ones and evidently of recent origin; (2) plants whose development from Entomophilae is not so evident, but which have dehiscent polyspermous fruits, one-seeded dehiscent fruits, or one-seeded indehiscent fruits developed from pistils containing more than one ovule; (3) in large groups containing no entomophilous representatives, having one-seeded indehiscent fruits ripening from one-celled, one-ovuled pistils.

The considerable number of plants of the first set shows that the independent development of anemophilous plants from entomophilous ones has frequently taken place. It shows that the change is easy. The most recent cases are of genera belonging to entomophilous groups, which are themselves entomophilous, but contain anemophilous species: Thalictrum, Fraxinus, Sanguisorba (Poterium), Acer; Salix, also, if Warming is right in regarding the Greenland species of Salix as anemophilous.[1] Less recent are Ambrosia in Helianthoideae, Ricinus in Euphorbiaceae, Rumex in Polygonaceae, Platanus in Rosales, Amarantaceae in Centrospermales, Plantaginaceae in Sympetalae, Juncaceae in Liliales. On the other hand, none of the anemophilous groups have produced forms which could reasonably be regarded as recently developed entomophilous ones.

In the recent cases the fruit does not differ essentially from that of the entomophilous forms from which they were derived.

The Plantaginaceae compose the only anemophilous family of Sympetalae and show every indication of being recent. The stigma is single, but is, no doubt, modified from a completely compound one. The number of seeds varies greatly, but some of the flowers are subject to spontaneous self-pollination and others may be more or less etomophilous.

Populus has two to four stigmas, a syncarpous fruit with two to four valves, two to four parietal placentae, and numerous coma-bearing seeds. From these characters I would suppose that Populus was not only of entomophilous origin, but recent. It has seemed to me remarkable that Müller should have regarded Populus as a primitive anemophilous form and Salix as a recent entomophilous form derived from the same stock. For the relatives of Salicaceae I would look among the entomophilous polyspermous forms having similar fruit and seeds. So, from my standpoint, and in the absence of some other consideration, I would readily accept the view that the Salicaceae should follow the Tamaricaceae, the reduction of the flowers being correlated with close crowding in a specialized inflorescence. In regard to the entomophilous origin of Populus, it may be mentioned again that Warming regards the several species of Salix occurring in Greenland as anemophilous.

---

[1] Om nogle grönlandske blomster. Sv. V. Ak. Öfv. 1886: 116, 131, 158.

The relation of Amarantaceae to an entomophilous group and its recent anemophilous character is implied by the position to which it has been assigned. Some of the family are entomophilous and polyspermous. The more familiar anemophilous species are monospermous, but still retain the useless habit of opening to discharge a single seed.

Betulaceae has a pistil with two stigmas and a two-celled ovary with one ovule in each cell. The fruit is one-seeded and indehiscent, but was evidently developed from a polyspermous one.

Fagaceae usually has three stigmas, three-celled ovaries, with two ovules in each cell, ripening into one-seeded fruits. Sometimes, however, in Castanea, the fruit contains two or three seeds, although it has lost the power of discharging them. Here we have evidence of a change from a polyspermous, entomophilous condition.

The Juglandaceae have a pistil with two stigmas and an incompletely two to four-celled, one-ovuled ovary. The fruit is apparently syncarpous and the anemophilous condition only a stage in advance of that of the Betulaceae.

The Ulmaceae appear to be syncarpous. Ulmus has a pistil with two stigmas, a one to two-celled ovary with one to two ovules, and the fruit monospermous. Morus has two stigmas and a two-celled ovary.

The Juncaceae are placed in the entomophilous group of Liliales. Some of the species are entomophilous, others autogamous or cleistogamous. The anemophilous ones are polyspermous, indicating a recent entomophilous origin. The fruit is evidently tricarpellary.

On the supposition that the Typhaceae are representatives of primitive anemophilous monocotyledons, it is hard to account for the fact that Sparganium sometimes has two stigmas and a two-celled, two-ovuled pistil ripening into a two-seeded indehiscent fruit. Typha has the fruit dehiscent, although one-seeded, and the pollen in fours. The occurrence of persistent tetrads is of itself enough to establish a presumption of an entomophilous origin. Such compound pollen grains occur in Anonaceae, Magnoliaceae, Empetraceae, Ericaceae, Vacciniaceae, Epacridaceae, Pyrolaceae, Onagraceae, Amaryllidaceae, and Juncaceae—all entomophilous except the last. In connection with the case of Typha may be mentioned the statement of Bentham and Hooker that some Araceae have "pollen in farciminula conglomeratum (pollen vermiforme)." The Typhaceae seem to be anemophilous descendants of the entomophilous Araceae. The reduction of the flowers seems to have been connected with close crowding on the spadix, followed by further reductions after the anemophilous habit was established.

In the Glumales we find a great group of anemophilous plants with the pistil one-ovuled and the fruit one-seeded. From the fact that the flowers are crowded in highly specialized inflorescences I would conclude that their seemingly simple structures are the result of degradation. The pistil has two or three stigmas, from which I conclude that the fruit is syncarpous and developed from a polyspermous stock. Anemophily may account for a stigma becoming plumose, but I do not see how it will account for the presence of two or three stigmas.

While I think the claims of any anemophilous plants which I know to being representatives of primitive anemophilous forms can be refuted without resorting to any speculative considerations, there are some speculative difficulties which may be mentioned. On the supposition that the angiospermous prototype was anemophilous, I can hardly imagine any conditions under which it would be advantageous for the ovules to become inclosed in a carpel. A single ovule could hardly be pollinated any better, and more than one could hardly be pollinated so well. If, on the other hand, the pollen was carried by insects, we can understand how a number of ovules might become inclosed in a carpel and be more effectively pollinated than they were before. So I am inclined to regard the angiospermous prototype as having been polyspermous and entomophilous. Here it may be well to cite the fact that the recently discussed cases of plants which are doubtfully dictoyledonous, or which seem to point more or less significantly to a line from which the dicotyledons and monocotyledons may have had a common origin, are entomophilous.

There are some considerations relative to pollinating agencies which may have had something to do with anemophilous metamorphosis. A change to wind pollination might be favored by close competition of entomophilous flowers for the attentions of anthophilous insects or by disturbances reducing the number of insects of that kind.

Some conditions in the behavior of bees may also have favored the resort of many diclinous plants to anemophily. The primitive anthophilous insects probably visited flowers chiefly for nectar. Adaptations to them were secured by placing the nectar so that the visitor in obtaining it would strike the anthers in one case and the stigma in the other. The advent of the bees, which feed their young principally on pollen, and whose most abundant and most efficient visits are for that purpose, has changed the conditions. The flowers best adapted to bees are those whose receptive stigmas are so near the dehiscing anthers that the bees cannot collect the pollen without coming in contact with the stigmas. Diclinous, dichogamous, and large flowers are often visited by bees which rarely touch the stigmas. The diclinous plants particularly seem to suffer from having their pollen carried away by female bees which pay little attention to the pistillate flowers. Under these conditions it is a question whether anemophily would be much more expensive or precarious for many diclinous entomophilous flowers.

In many cases the views here advanced are not supported by the Engler and Prantl classification, and involve a criticism of that system. But they are supported by the modification of the systems of Engler and Prantl, and Bentham and Hooker, proposed by Bessey in the BOTANICAL GAZETTE **24**: 145–178. 1897, and, as far as they go, tend to supplement his conclusions regarding the taxonomy of angiosperms That author says nothing about the mode of pollination, but the forms which he selects as primitive involve the conclusion that the original forms were entomophilous. Bessey places a number of controverted families in entomophilous groups: Salicaceae after Tamaricaceae in Caryophyllales; Urticaceae in Malvales; Fagaceae, Betulaceae, and Juglandaceae in Sapindales; Typhaceae with Aroideae in Nudiflorae. —CHARLES ROBERTSON, *Carlinville, Ill.*

ARCTERICA, THE RAREST GENUS OF HEATHERS.

(WITH TWO FIGURES)

IN the Harvard University Herbarium is a specimen of an ericaceous plant which has a singular and interesting history. The specimen is a mere fragment, 43^{mm} in length, yet its characters are so clear and remarkable that Dr. Asa Gray in 1885 described it as a new species, *Cassiope oxycoccoides*,[2] and the present writer, while segregating two species from Cassiope under the generic name Harrimanella in 1901,[3] found in this plant sufficient characters to warrant setting it aside as a third genus, Arcterica.

[2] GRAY, A., Proc. Am. Acad. **20**:300. 26 Ja 1885; GRAY in STEJNEGER, Proc U. S. Nat. Mus. 7:534. 27 Ja 1885.

[3] COVILLE, F. V., Proc. Wash. Acad. Sci. 3:569–576. *figs. 62–66.* 1901.